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Cavity-modified laser induced fluorescence of a blended system of polymer film

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Abstract Laser induced fluorescence spectrum in the range 5600-6900Å of a block of neat film of polymer blend system of Poly (1,4-Phenylene Vinylene) (PPV) and *p*-Benzoquinone (PBQ) has been obtained with the help of a 500 mW Ar^{+} (5145 Å) laser Drastic fluorescence quenching has been observed when this block of polymer blend system with a thickness of 2 5 mm, breadth 15 mm and length 15mm, is placed in an external cavity consisting of two dielectric mirrors separated by a distance of 20mm We have also observed substantial narrowing down of fluorescence in the higher wavelength side of the spectrum Our measurement also allows us to shed light on the fundamental question of energy transfer and gain mechanism

Keywords LIF, Quenching, Polymer film

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1. Introduction

A polymer is a very large molecule comprising hundreds of thousands of atoms formed by successive linking of one or two, occasionally more, types of small molecules into a chain or network structure. The repeating units are usually obtained from low molecular weight, simple compounds, referred to as monomers. The conversion process, monomer to polymer is known as "polymerization". The formation of polyethylene is a simple example of this process. Frequently the end groups of polymers are unknown. They may arise from impurities in the reaction mixture. In some cases, the end group of polymers can by controlled. However the properties of a polymer are governed entirely by the bulk of the polymer molecule rather than the end groups. Polymer and plastics possess distinctive features that have motivated their study as laser gain media, and high gain materials for solid state polymer lasers [1-10]. Particularly, conjugated polymers are believed to carry

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great promise for application as gain material in organic solid-state lasers They cover the entire visible spectral range and offer the prospect of being electrically driven The first electrically driven organic laser has been realized using a crystalline material [11] but lasing from conjugated polymers has so far been achieved in an optically pumped device In the first optically pumped thin film polymer laser a planar microcavity was employed [3] In a planar microcavity a polymer layer is sandwiched between two highly reflecting mirrors The laser light then propagates perpendicular to the active layer, just as in a vertical-cavity surface emitting semiconduting laser Since then various other optically driven polymer lasers have been reported, using a variety of cavity configurations [12,13,14] It is worthwhile to note that even non-conjugated polymers those with one carbon atom with a double bond followed by an array of atoms with single bonds can behave as conjugated polymer after they were doped with suitable materials This is contrary to the common believe that for a polymer to be able to conduct electric current, it must consist alternately of single and double bonds between the carbon atoms Poly (1 4-phenylene vinylene) has been the subject of great interest in recent years It has potential applications in light emitting diodes, light emitting electrochemical cell and plastic lasers [15,16] To improve its solubility and optical properties substituents are introduced to the main chain To study the luminescence properties in detail it is very important to explore the factors that can influence the luminescence In the present work we are concerned with the laser induced fluorescence of a neat polymer film consisting of a blended system of PPV and a luminescent organic molecule PBQ We report here that the fluorescence spectrum undergoes drastic changes in its intensity and narrows down considerably when placed in an external cavity

2. Experimental

In the present experiment we have used poly (*p* -phylenevinylene) (PPV) ad p-benzoquinone (PBQ) of reagent grade PBQ was blended into PPV matrix in the ratio of 20% by weight The material prepared is dissolved in an organic solvent acetone and kept in a cell for 48 hours. Acetone evaporates and leaves behind a jellylike neat film of the blended mixture It is possible to prepare neat polymer films of different dimensions and in this experiment the film of dimension of thickness 2 5 mm, breadth 15 mm and length 15mm has been used. An argon ion laser (500mW all lines) is used for exciting the fluorescence of the sample and the exciting radiation is 514 nm The salient feature of the experiment is that the laser radiation is allowed to fall on the sample and the fluorescence is observed on a spectrograph in the same direction. The fluorescence is recorded on a commercially available film. A bright fluorescence is observed in the red-yellow sector of the spectrum In this work we also compared this fluorescence with that observed when the blended system of polymer is placed inside a cavity constructed between two dielectric mirrors The intensity of the fluorescence spectra is measured with the help of a computer, a scanner, a printer and a software designed specifically for the purpose

3. Results and discussion

Figure 1(A) shows the fluorescence spectrum of the PBQ/PPV system in the red-yellow sector ranging from 5500 to 7000 Å. This fluorescence system undergoes dramatic change in shape when the sample is placed inside the cavity. As may be seen is Figure 1(B) a discrete band appears at 6750 Å and the entire spectrum narrows down to diffuse band within the wavelength range of 5800 Å to 6000 Å This indicates conclusively that the fluorescence system is affected by the cavity and the mechanism is analogues to gain narrowing process. It is also seen that when the PBQ and PPV ratio is changed (PBQ is 50% by weight) fluorescence spectrum undergoes further modification in shape as shown in Figure 1 (C), when the system is placed in the cavity The discrete band at 6750 Å

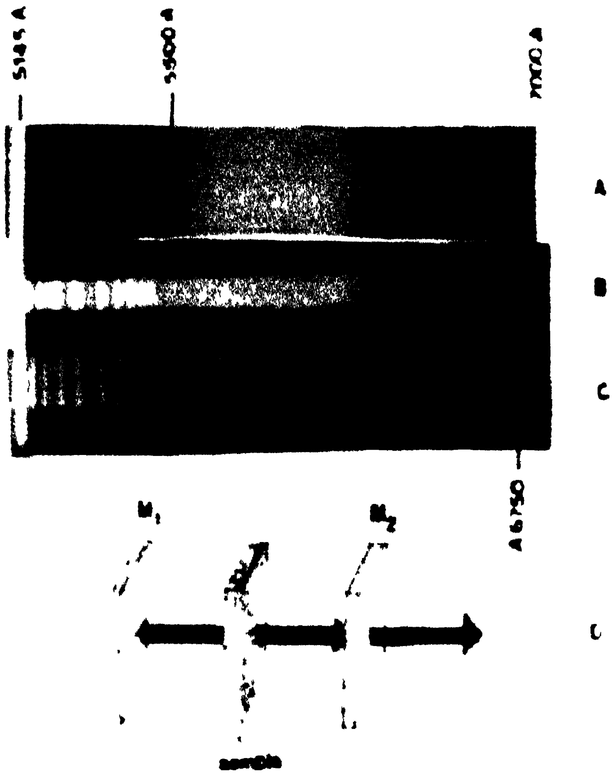

Figure 1. Laser induced fluorescence spectra of the blended system of PPV/PBQ

disappears. Figure 2 shows the nature of the measured intensity of the fluorescence spectra of the blended systems. It may be noted that PBQ is a well known organic material exhibiting fluorescence and emission in the visible region [17-18]. The present experimental observations is an example of modification of fluorescence in the presence of cavity. Wegmann *et al.* [19] presented measurement which indicated laser emission from π conjugated polymer blend system when placed into an external cavity. From the present work it is difficult to say whether the modified spectra are due to stimulated emission or it is simply a narrowed down fluorescence spectrum. In either case, our observations allow us to throw light on the fundamental question of gain mechanism in this class of material. Energy transfer form PBQ to PPV and *vice versa* is important parameter to be investigated. In conclusion, we may indicate that blending an optically active material in a polymer matrix and placing the system in external resonator affects the fluorescence A system of this type may serve as an excellent material for polymer laser

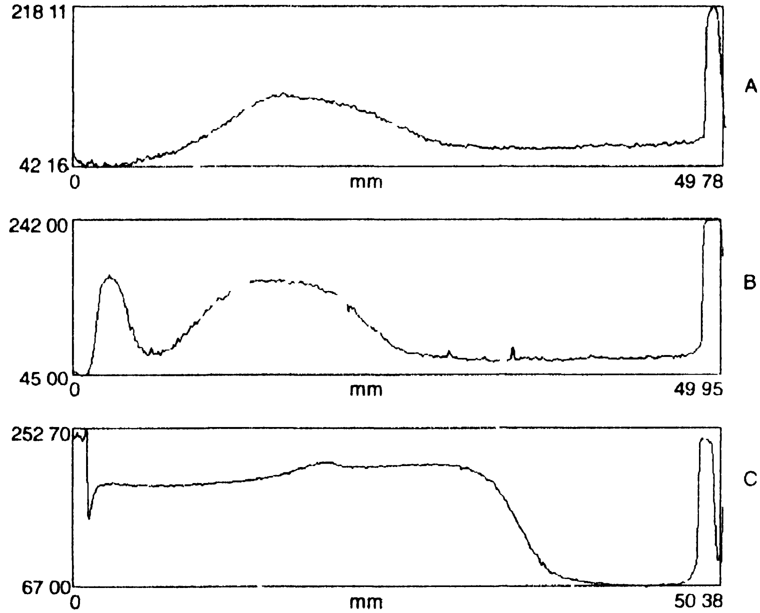

Figure 2. The fluorescence spectra of the blended system (A) Without cavity (B) With cavity PBQ is 20% by weight and (C) PBQ is 50% by weight

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